AC:

AC CAPACITIVE CIRCUITS

Unclassified

3 Hour Conference, W/ 4Hr PE1

Safety & Environmental Impact is

OW'

“Discharge Hazard”.

AC: Capacitors

Terminal Learning Objective

ACTION:

Calculate Capacitive Reactance, Impedance & the operating parameters of an RC type Ckt.

CONDITIONS:

With Official OMEMS Training Aid reference.

STANDARD:

A minimum accuracy 7of 10 correct answers, or 70%.

AC: Capacitors

Introduction

In the previous lesson we dealt with the Inductor, a component that is frequency sensitive. In this lesson we will look at the Capacitor. Its value of opposition will also change w/the change in frequency.

The Capacitor is a reactive component & since its opposition cannot be measured it must be calculated.

Cap Symbols

AC: Capacitors

CAPACITOR {Cap};

Opposes any **change in Voltage** & stores energy in a Electrostatic Field.

It **Blocks DC** & **Passes the Effects** of **AC**.

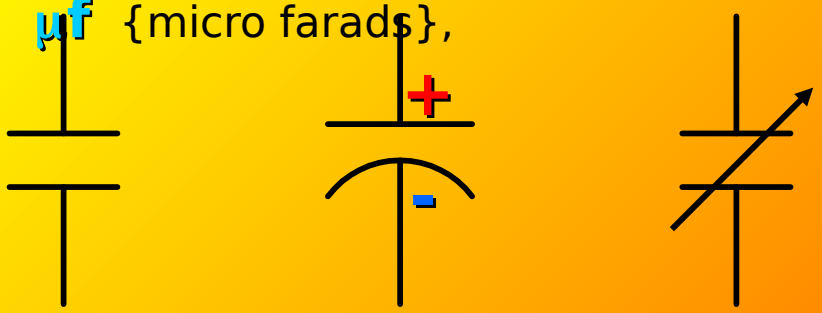
Schematic Letter Symbol; C C_1 C_2...

Unit of Measure; **Farads,** f {lower case}

fd

µf {micro farads},

Schematic Symbols;



FIXED **ELECTROLYTIC**

VARIABLE

Cap Electrolytic

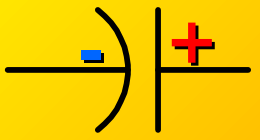
AC: Capacitors Concepts

CAP, Electrolytic;

Wiring integrity must be observed. The <u>Negative</u> side normally oriented <u>toward ground</u>.

Observe polarity by the indication on the case, there may be a black strip indicating the Negative lead.

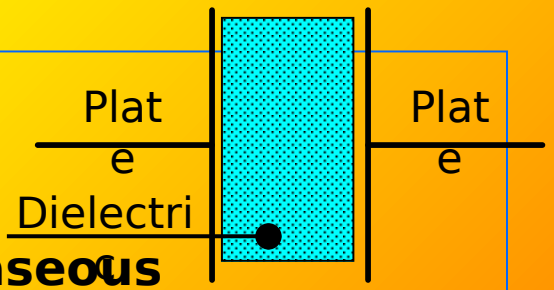
Wiring in reverse creates a Hazard.



CAP, 3 Basic Parts;

2 Plates.

Dielectric; A solid, liquid or gaseous material that can sustain an Electrostatic Charge and act like an Insulator.



Dielectric & Value

AC: Capacitors Introduction

CAPACITANCE;

The Value of a capacitor is dependent on several factors.

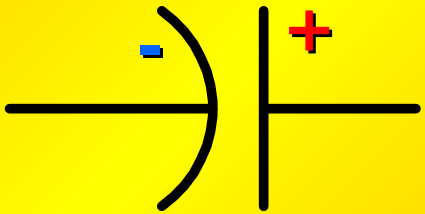
The area of the plates; [surface area]

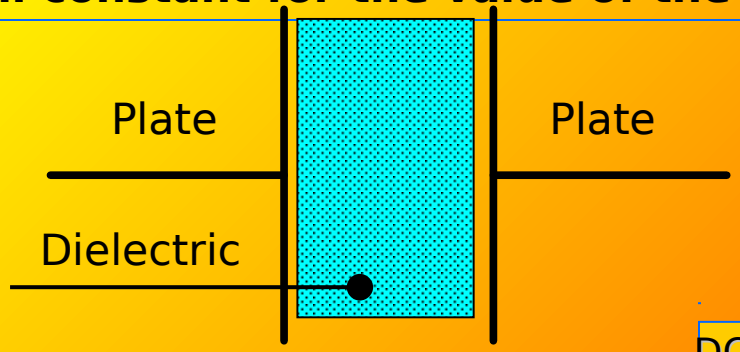
Distance between the Plates;

The greater the distance between the plates, the less the capacitance. The effect of charged particles is less as distance increases.

Type of dielectric;

Air, Mica, Glass, Quartz, Castor oil, Vacuum, provides the mathematical constant for the value of the Cap.

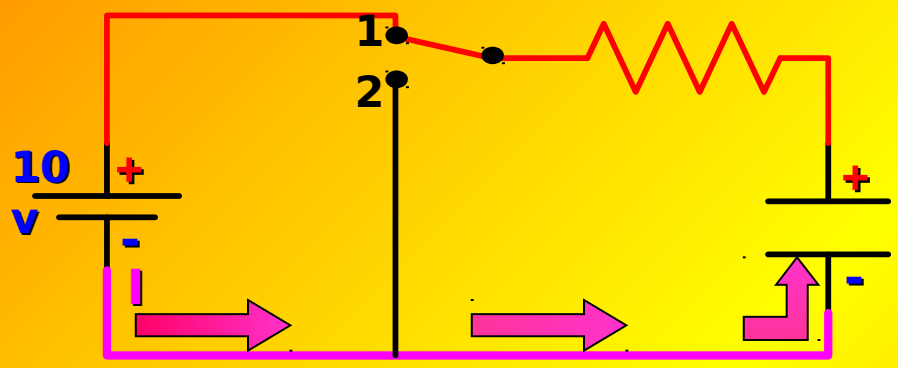




DC-Charge & Dis.

AC: Capacitors Concept

CAPACITOR, Charge & Discharge;

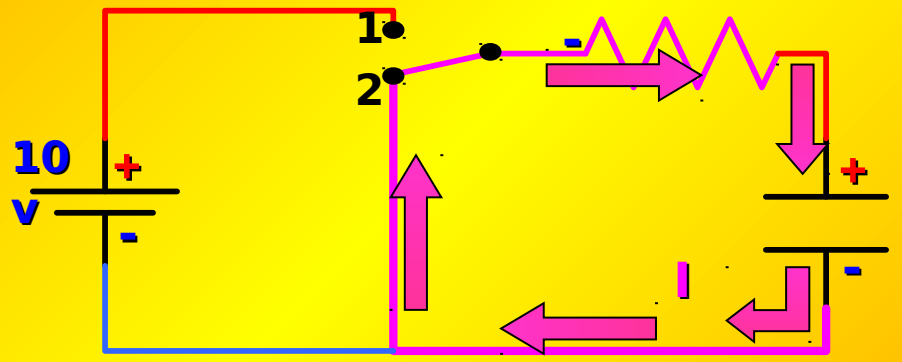


Charge path;

A Cap will only charge up to the Voltage Applied.

Current will flow to, but not through a Cap.

A Cap will hold a charge until a path is established for discharge.



Discharge path;

When A cap's discharges current will leave the cap in the opposite direction.

Current will flow to the most positive point in the Ckt.

CT; Parallel

AC: Capacitors, CT

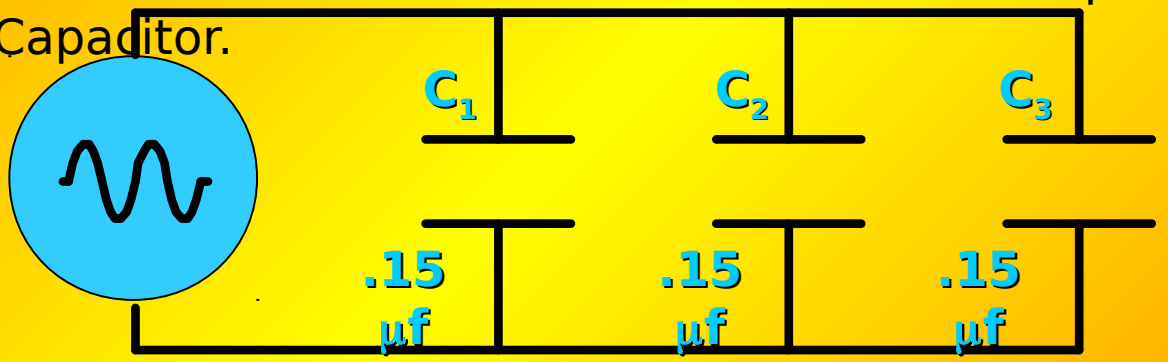
Calculating for CT;

The objective is to reduce the capacitor values down to a single value of Capacitance { C_T }.

Capacitors in Parallel;

Are calculated like Resistors in series. $C_1 + C_2 + C_3 \ldots = C_{EQ}$.

This is due to the surface area of the plates acting as 1 Capacitor.



Note:

CEQ & CT are equal in a pure Parallel Ckt.

$C_1 + C_2 + C_3 \ldots = C_{EQ}$

$.15\mu f + .15\mu f + .15\mu f = .$

CT; Series

AC: Capacitors CT

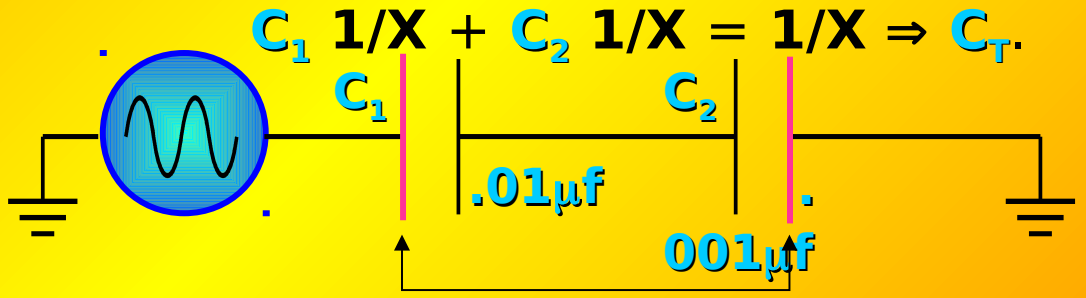
Capacitors in Series;

Are calculated like Resistors in Parallel.

This is due to the area between the plates.

Like Value, Product over the Sum, Reciprocal.

C_T will be smaller than the smallest Cap.



.01μf 1/X + .001 μf 1/X = 1/X ⇒ .0009 μf

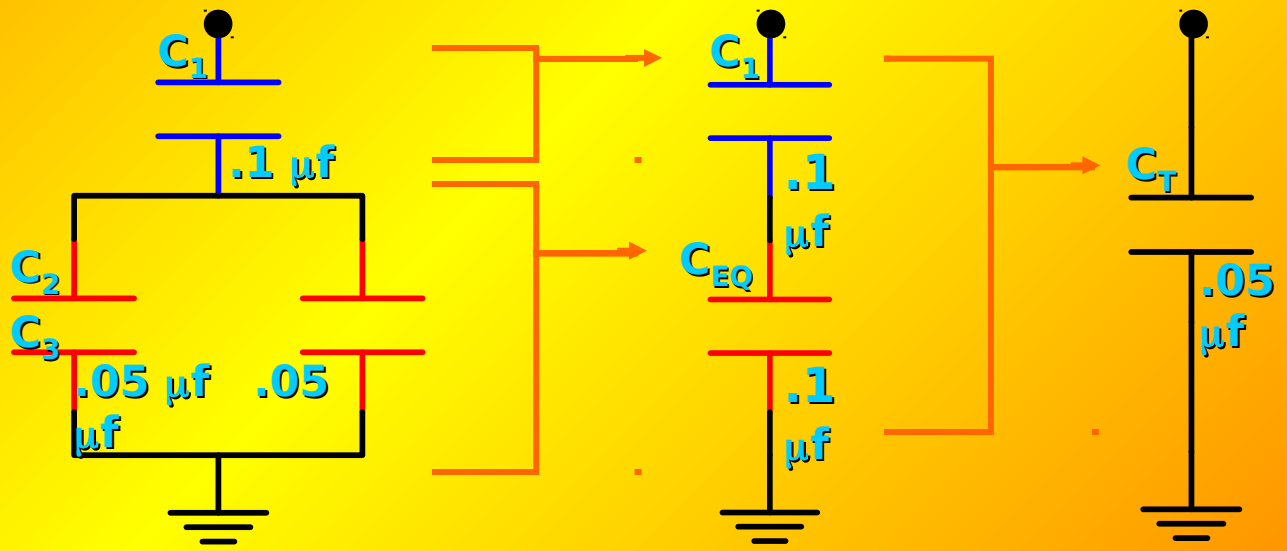
AC: Capacitors CT

Capacitors in Series & Parallel;

The Series portion is calculated like Resistors in Parallel.

The Parallel portion is calculated like Resistors in Series.

The Reduction of the Parallel portion puts the Caps in Series, therefore they must be calculated like resistors in Parallel, to acquire a single value of capacitance, { CT }.



ADD the Parallel → then find the **Reciprocal** → this will = **CT**

XC

AC: Capacitors, XC

Capacitive Reactance;

Capacitors like Inductors are frequency sensitive devices. Since their opposition cannot be measured it must be calculated with Frequency as part of the equation.

1 Over 2 Pies For

$$\frac{1}{2\pi F C} = X_C \text{ in } \Omega$$

6.28 X Frequency X Capacitor 1/X ⇒ XC

6.28 X 10 KHz X .001μf 1/X ⇒ 15.923

On the Calculator: 6.28 X 10 EE 3 X .001 EE -6 = 1/X ⇒ 15923. = 15.9KΩ

Challenge

AC: Capacitors Relationship

Calculate Capacitive Reactance XC ; 3 places, NO Rounding.

Freq = 6 KHz	Cap = 3 μf	X_C = _____
Freq = 8 KHz	Cap = 3 μf	X_C = _____
Freq = 10 KHz	Cap = 3 μf	X_C = _____

$$\frac{1}{2\pi F C} = X_C \text{ in } \Omega$$

Freq = 10 KHz	Cap = 4 μf	X_C = _____
Freq = 10 KHz	Cap = 8 μf	X_C = _____
Freq = 10 KHz	Cap = 10 μf	X_C = _____

6.28 X Frequency X Capacitor = 1/X ⇒ X_C

Answers

AC: Capacitors Relationship

Calculate Capacitive Reactance X_C ; An Inverse Relationship.

Freq = 6 KHz	Cap = 3 μf	X_C = 8.846 Ω
Freq = 8 KHz	Cap = 3 μf	X_C = 6.634 Ω
Freq = 10 KHz	Cap = 3 μf	X_C = 5.307 Ω

$$\frac{1}{2\pi F C} = X_C \text{ in } \Omega \qquad E_C$$

Freq = 10 KHz	Cap = 4 μf	X_C = 3.980 Ω
Freq = 10 KHz	Cap = 8 μf	X_C = 1.990 Ω
Freq = 10 KHz	Cap = 10 μf	X_C = 1.592 Ω

6.28 X Frequency X Capacitor = 1/X ⇒ X_C

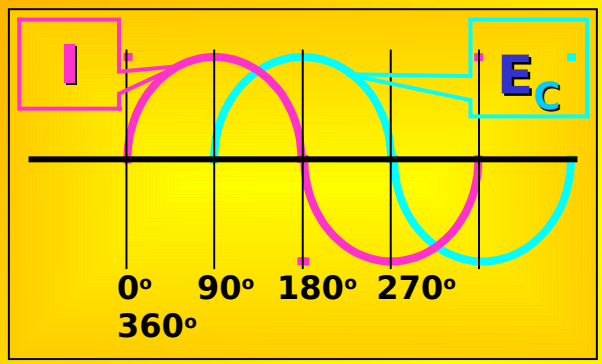
Phase

AC: Capacitors, Phase Relationsh

Phase Relationship;

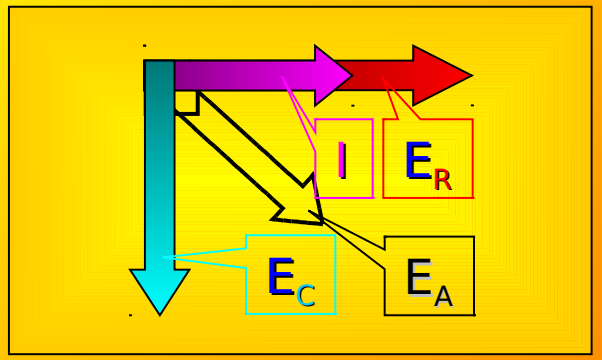
Current leads Voltage by 90°

Eli the I C E man is 90 years old



SINE; 90° out of Phase;

Current, (I) leads Voltage in a Capacitor (EC), by 90°.



Vector; 90° out of Phase;

Current, (I) leads Voltage in a Capacitor (EC), by 90°.

Z

AC: Capacitors, Impedance

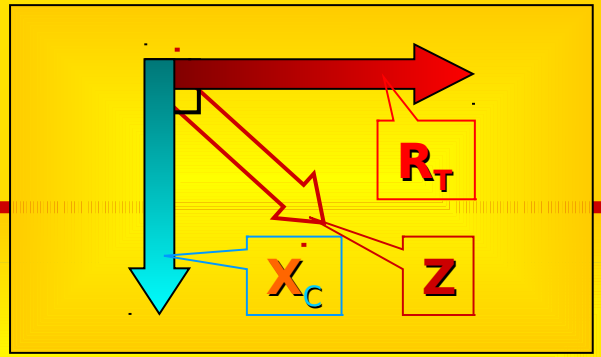
Impedance { Z }:

The TOTAL OPPOSITION to AC.

Z

Ω

A Ckt of Resistors [non-reactive] **& Capacitors** [reactive]; **the total opposition must be calculated Vectorally**



$$Z = \sqrt{R_T^2 + X_{CT}^2}$$

On the Calculator;

R X^2 + XC X^2 = $\sqrt{X}$ ⇒ Z in Ω

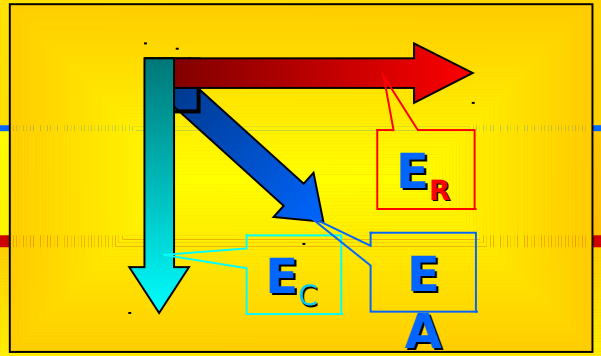
Once Impedance is determined, all other operating parameters in a Ckt can be calculated.

EA

AC: Capacitors, Applied Voltage

Applied Voltage, { E_A };

Because the opposition was added using Vector Addition, the Voltage Applied will have to be added the same way.



$$E_A = \sqrt{E_{RT}^2 + E_{CT}^2}$$

On the Calculator;

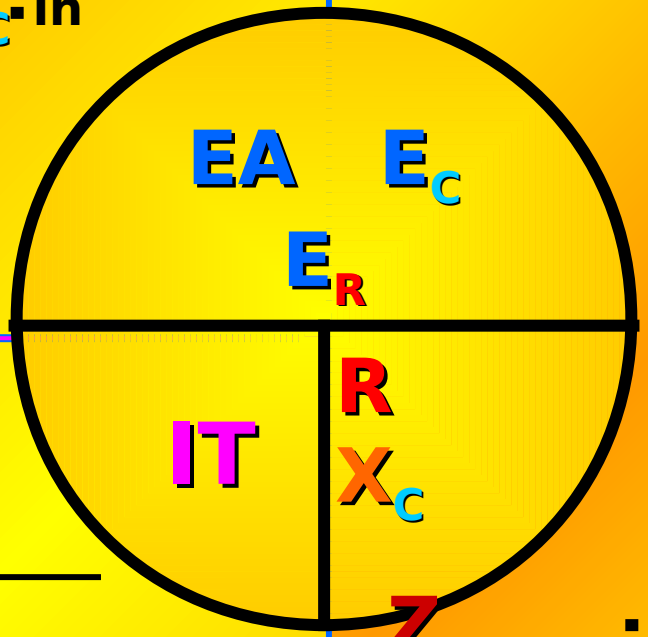
E_{RT} X^2 + E_{CT} X^2 = $\sqrt{X}$ ⇒ E_A

Ohms Law

AC: Capacitors Concept

Calculating the Operating parameters; Sequence.

$$\frac{1}{2\pi F C} = X_C \text{ in } \Omega$$



$$Z = \sqrt{R_T^2 + X_{CT}^2}$$

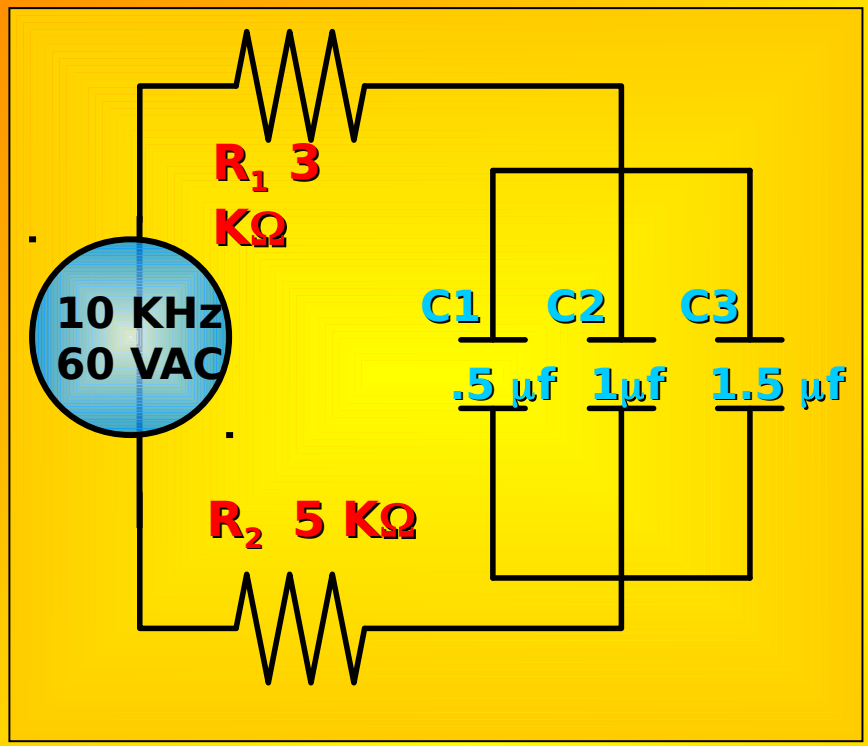
$$EA = \sqrt{E_{RT}^2 + E_{CT}^2}$$

C_{EQ}
C_T
R_T
$X_{C\#}$
X_{CT}
Z
I_T
$E_{R\#}$
E_{RT}
$E_{C\#}$
E_{CT}
EA

Challenge

AC: Capacitors Challenge

Calculate Operating parameters; 3 Places, No Rounding.



$C_1 + C_2 + C_3 =$ C_T

$R_1 + R_2 =$ R_T

$2\pi F C_1 = 1/X \Rightarrow$ X_{C1}

C_2 X_{C2}

C_3 X_{C3}

$2\pi F C_T = 1/X \Rightarrow$ X_{CT}

$R_T^2 + X_{CT}^2 =$ Z

$EA / Z =$ I_T

C_T TO I_T Answers

$I_T \times R_1 =$ E_{R1}

$I_T \times R_2 =$ E_{R2}

$I_T \times R_T =$ E_{RT}

$I_T \times X_{CT} =$ E_{C1}

$I_T \times X_{CT} =$ E_{C2}

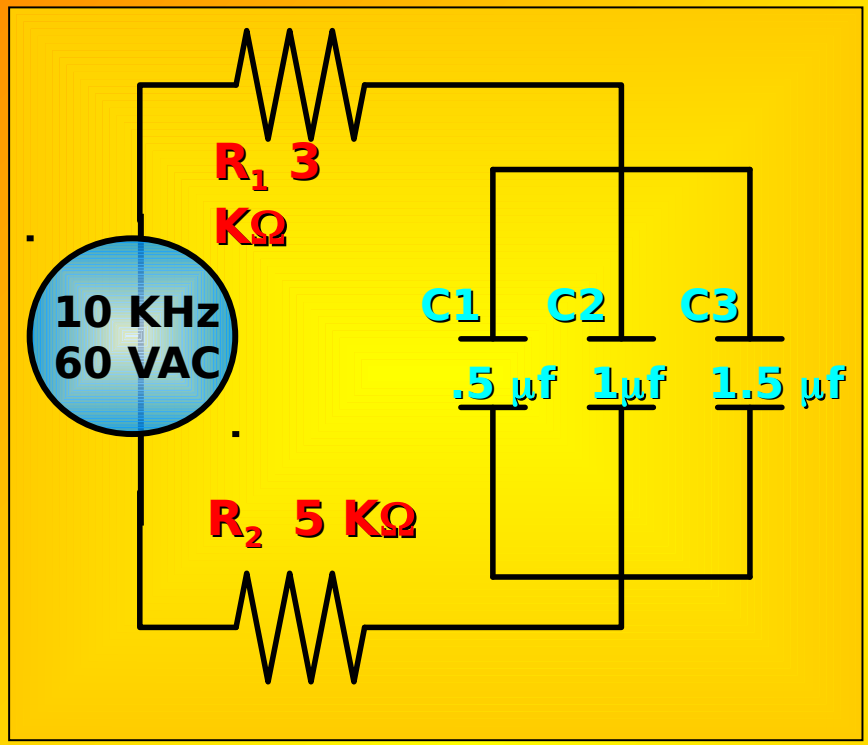
$I_T \times X_{CT} =$ E_{C3}

$I_T \times X_{CEQ} =$ E_{CEQ}

$\sqrt{E_{RT}^2 + E_{CEQ}^2} =$ EA

AC: Capacitors Challenge

Calculate Operating parameters; 3 Places, No Rounding.



$C_1 + C_2 + C_3 =$ $C_T = 3\ \mu f$

$R_1 + R_2 =$ $R_T = 8\ K\Omega$

$2\pi F C_1 = 1/X \Rightarrow$ $X_{C1} = 31.847\ \Omega$

C_2 $X_{C2} = 15.923\ \Omega$

C_3 $X_{C3} = 10.615\ \Omega$

$2\pi F C_T = 1/X \Rightarrow$ $X_{CT} = 5.307\ \Omega$

$\sqrt{R_T^2 + X_{CT}^2} =$ $Z = 8\ K\Omega$

$EA / Z =$ $I_T = 7.5\ mA$

Answers

$I_T \times R_1 =$ _____ E_{R1} _____ E_{C1}

$I_T \times R_2 =$ _____ E_{R2} _____ E_{C2}

$I_T \times R_T =$ _____ E_{RT} _____ E_{C3}

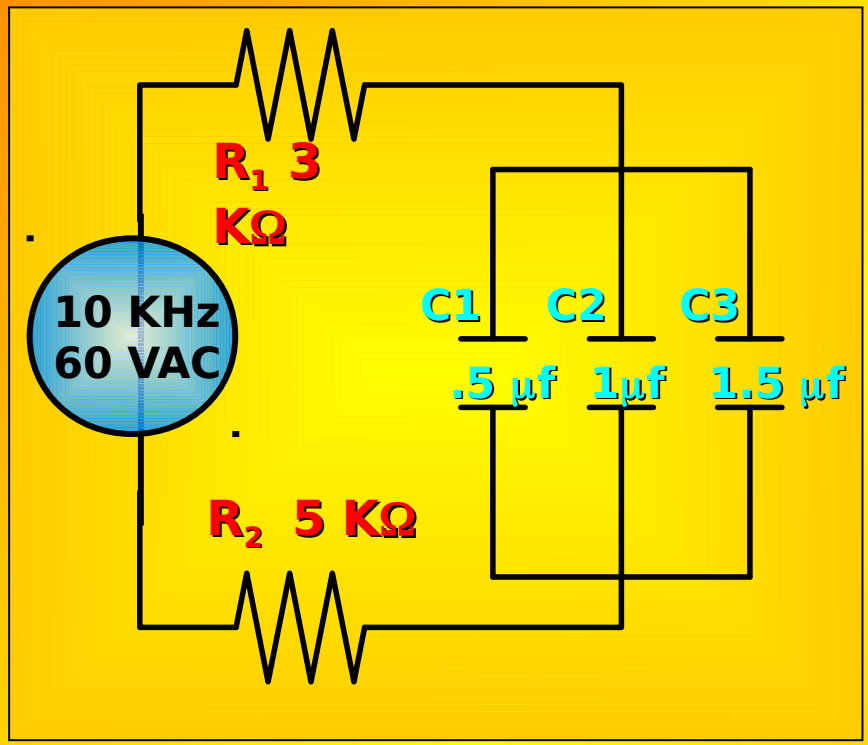
$I_T \times X_{CEQ} =$ _____ E_{CEQ}

$\sqrt{E_{RT}^2 + E_{CEQ}^2} = EA$

Note:
CT & CEQ are = .

AC: Capacitors Challenge

Calculated Operating parameters; 3 Places, No Rounding.



$C_1 + C_2 + C_3 =$ $C_T = 3\ \mu f$

$R_1 + R_2 =$ $R_T = 8\ K\Omega$

$2\pi F C_1 = 1/X \Rightarrow$ $X_{C1} = 31.847\ \Omega$

C_2 $X_{C2} = 15.923\ \Omega$

C_3 $X_{C3} = 10.615\ \Omega$

$2\pi F C_T = 1/X \Rightarrow$ $X_{CT} = 5.307\ \Omega$

$\sqrt{R_T^2 + X_{CT}^2} =$ $Z = 8\ K\Omega$

$EA / Z =$ $I_T = 7.5\ mA$

$I_T \times R_1 =$ $E_{R1} = 22.5\ V$ $I_T \times X_{CT} =$ $E_{C1} = .039\ V$ $I_T \times X_{CEQ} =$ $E_{CEQ} .039\ V$

$I_T \times R_2 =$ $E_{R2} = 37.5\ V$ $I_T \times X_{CT} =$ $E_{C2} = .039\ V$ $= 60\ V$

$\sqrt{E_R^2 + E_{CEQ}^2} = EA$

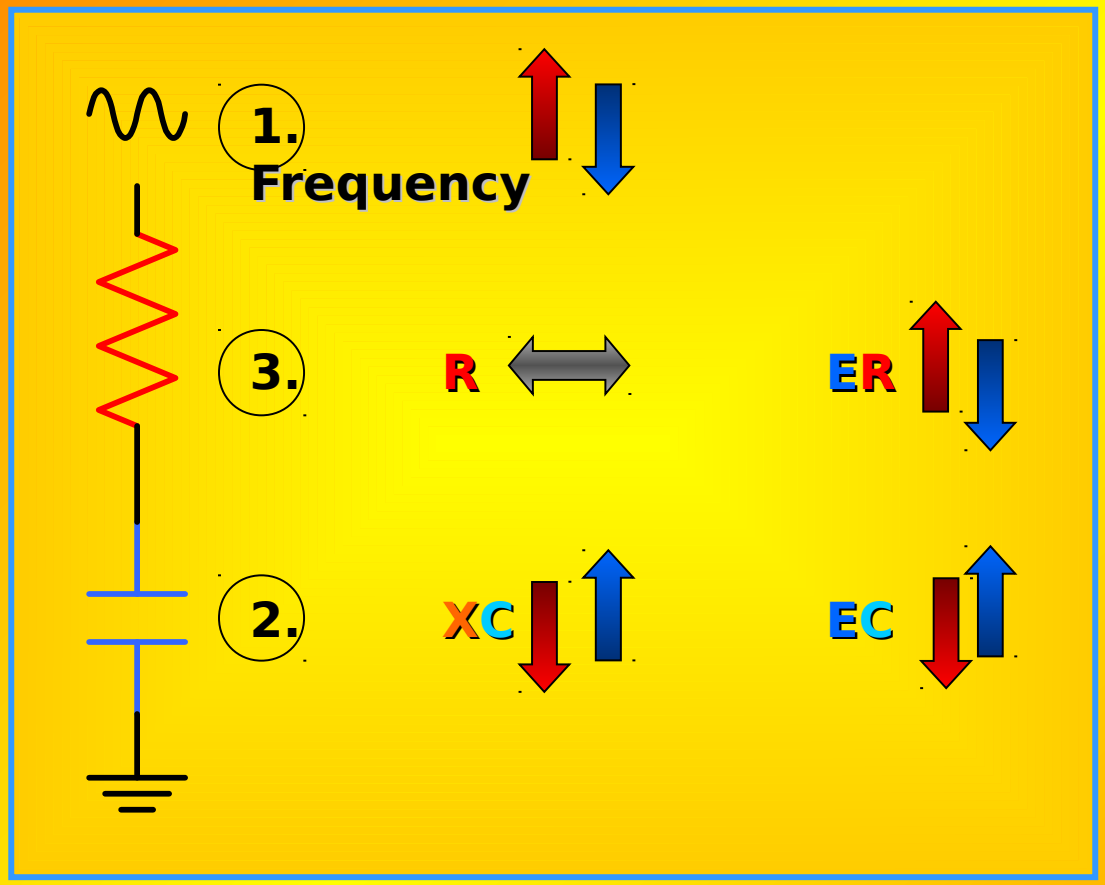
Note: CT & CEQ are = .

$I_T \times R_T =$ $E_{RT} = 60\ V$ $I_T \times X_{CT} =$ $E_{C3} = .039\ V$

Concept

AC: Capacitors Concept

Relationship; In an RC type Ckt.



IF the **Frequency** ⇧ the **XC** ⇩ so the **Voltage Drop** of the cap **[EC]** ⇩ **.**

If the **EC** is ⇩ **Kirchhoff's Law** dictates that the **Voltage Drop** of the **resistor [ER]** must ⇩ **.**

The inverse is true if the Freq Decreases.

Bench test Cap

AC: Capacitors concepts

Bench test a Cap; Ohms Check.

A cap placed within the Ckt cannot be checked using an Ohms setting. By removing the Cap from the Ckt it can be checked.

3 conditions of a defective Cap; OPEN, SHORT, RESISTIVE.

NORMAL; Place the leads across the cap & reverse meter while watching the meter, the should go to Zero then return to Infinity.

OPEN; Will stay at infinity in both directions.

SHORT; Will read Zero in both directions.

RESISTIVE; Will read resistive in both directions.

Problem Sheets

In a later lesson Signal Analysis will be introduced, a method of checking a Cap w/in the Ckt

AC: Capacitors, Problem Sheets

1. The opposition to AC offered by a Capacitor is called ?

   A. Impedance C. Capacitance

   B. Resistance D. Capacitive Reactance

2. What is the formula for computing Capacitive Reactance?

   _____

3. Refer to *Fig 1;* Calculate the Capacitive Reactance [XC]. _____

4. Refer to *Fig 1;* If R1 is shorted, what would happen to ckt Impedance ? _____

5. Refer to *Fig 1;* Calculate [Z] for the Ckt. _____

6. Refer to *Fig 1;* Calculate [IT] for the Ckt. _____

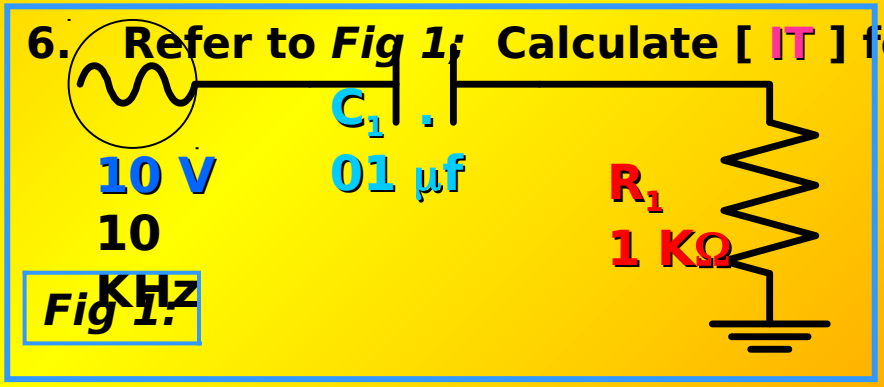
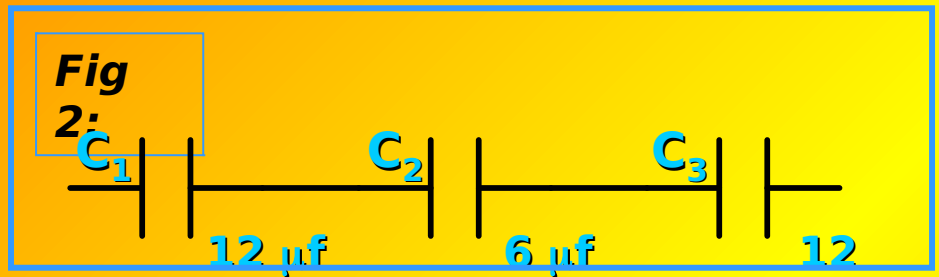


Fig 1.

Answers

AC: Capacitors Problem Sheets

7. Refer to *Fig 2;* Calculate CT for the Ckt. _____



8. By how many degrees does the current { *LEAD* or *LAG* } the Voltage over a Cap ? _____

9. If the ER = 12 V and EC = 16 V, what is EA ? _____

10. If R = 6 KΩ & XC = 8 KΩ , what is Z ? _____

11. If the applied <u>Frequency is Increased</u> in a capacitive circuit, what would happen to the <u>XC</u> ? _____

Answers 7-11

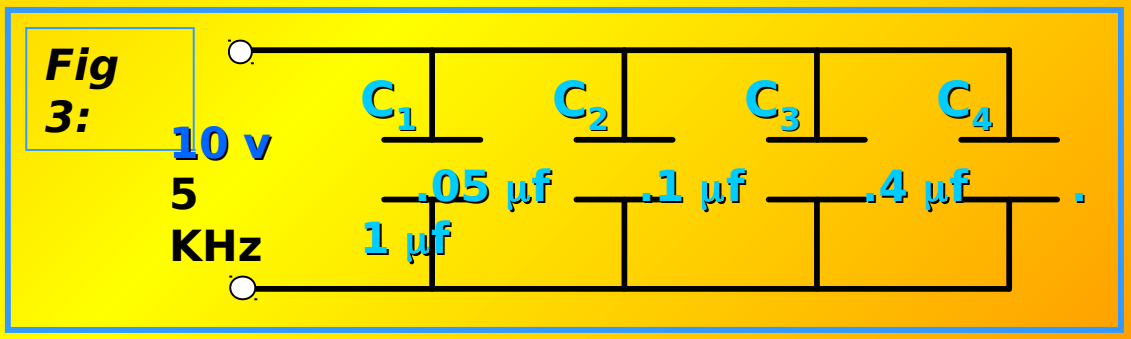
AC: Capacitors Problem Sheets

12. Refer to *Fig 3;* Calculate Total Capacitance.

_____

13. Refer to *Fig 3;* If C1 were to open, what would be the Voltage across C2 ? _____

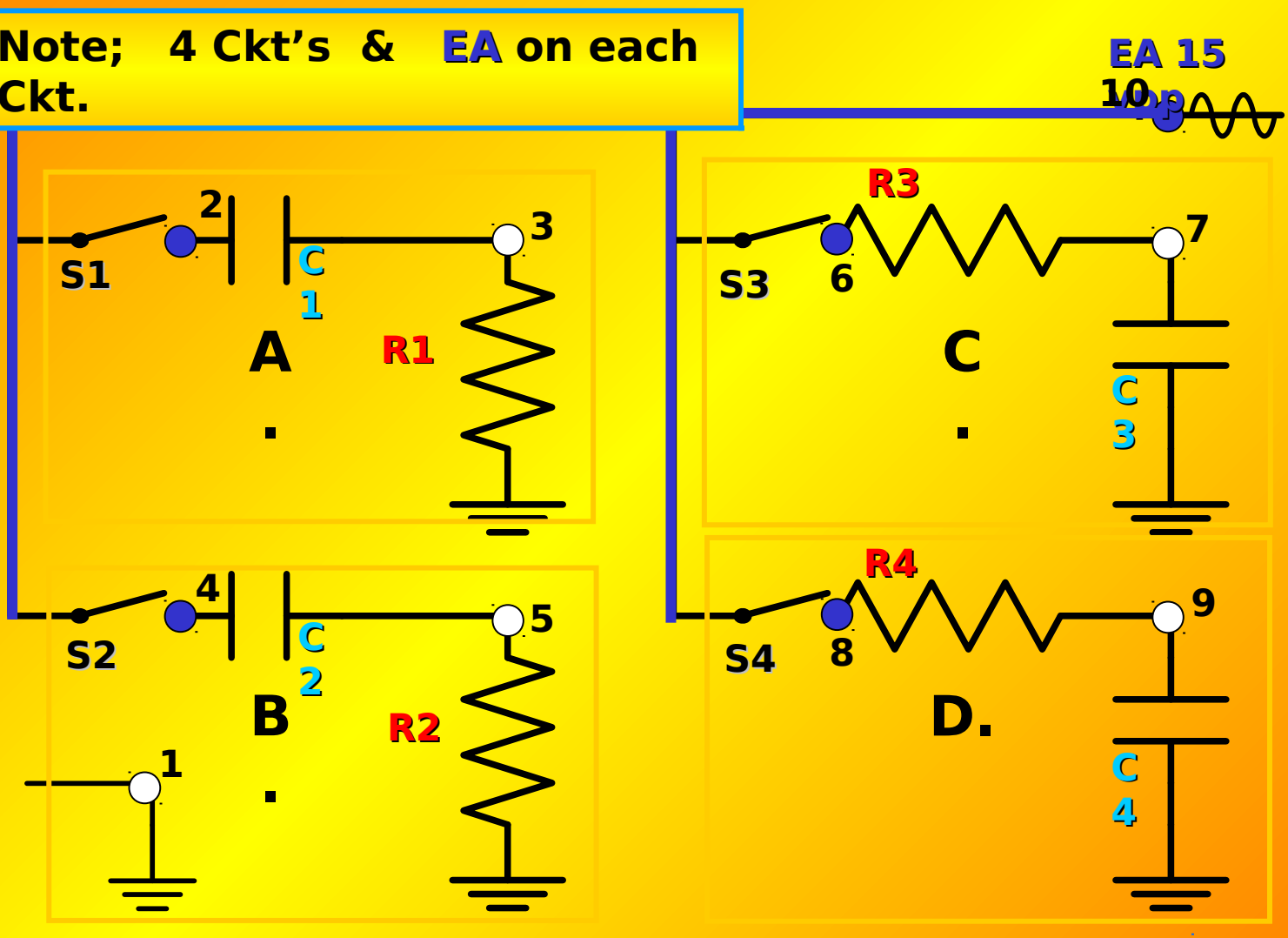
14. Refer to *Fig 3;* If C2 were to short, what would be the Voltage across C1 ? _____



Answers 12-14

AC: Capacitors, PE

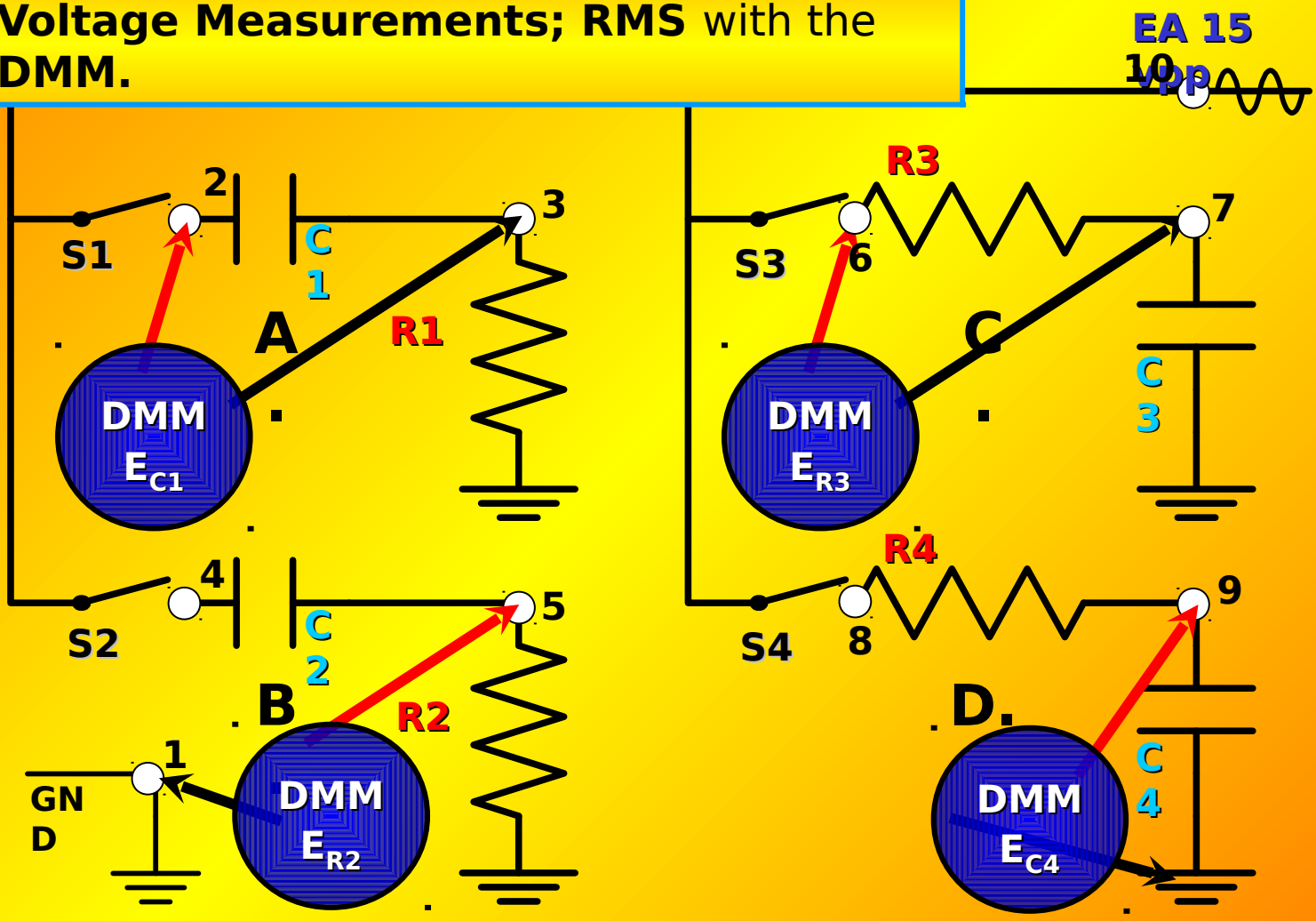
Note; 4 Ckt's & EA on each Ckt.



Measurements

AC: Capacitors PE

Voltage Measurements; RMS with the **DMM.**

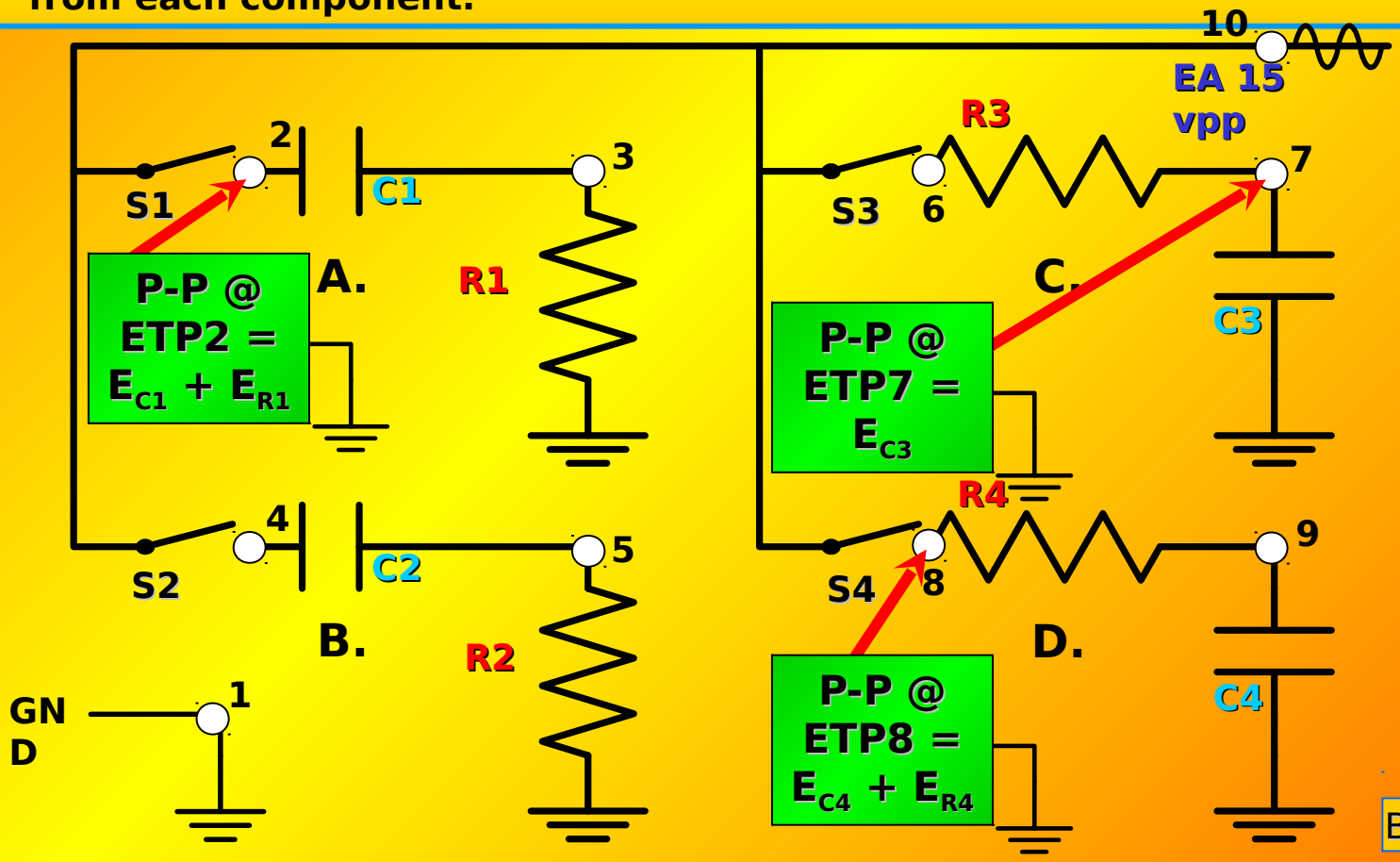


W/O-Scope.

AC: Capacitors PE

Voltage Measurements; P-P with the **O-Scope.**

All measurements made w/ the O-Scope are made in reference to ground, like the voltages @ test-points in DC. Every component between the Probe placement & Gnd is the sum of the voltage drops from each component.



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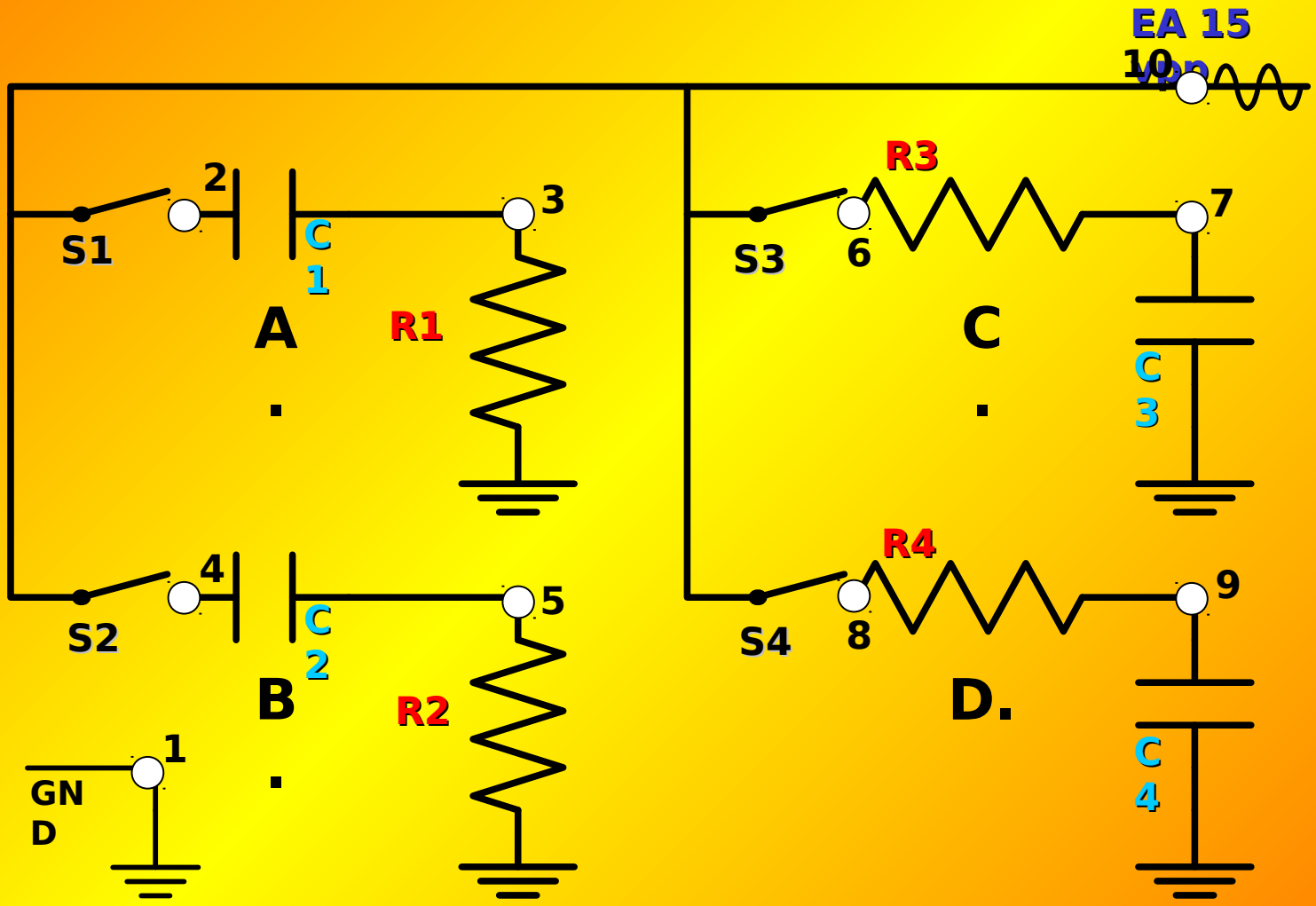
AC: Capacitors PE



Finish

AC: Capacitors Circuits

SUMMARY & QUESTIONS;

LESSON TEST;

Time; **20 Minutes.**

References; **Official OMEMS Training Aids.**

Standard; **7 of 10 questions answered correctly.**